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1982

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Nijkamp, P., & Spronk, J. (1982). *Integrated policy analysis by means of interactive learning models*. (Serie Research Memoranda; No. 1982-5). Faculty of Economics and Business Administration, Vrije Universiteit Amsterdam.

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INTEGRATED POLICY ANALYSIS BY MEANS OF INTERACTIVE LEARNING MODELS

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Researchmemorandum 1982-5 Januari 1982

Abstract

This paper aims at providing an operational methodological background for policy analysis based on interactive policy strategies. After a discussion of interactive multiple goal programming models, an empirical illustration based on an integrated Western European model is presented.

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1. Policy Analysis in Perspective

The quantitative approach to policy analysis has been a dominating feature in decision theory since the early works of Tinbergen (1956) and Theil (1968). Operations research has paved the way for the use of models in economic, environmental and energy policy problems, even on a global scale. Especially programming models have become very popular in the area of planning and policy analysis.

The use of such models and techniques however, has also met strong resistance due to the stringent assumptions underlying such advanced mathematical tools (apart from the complexity of these models). Usual assumptions regarding mathematical models for planning policy analysis are :

- the existence of a single clearly identifiable and unambiguous decision unit or policy unit which is able to steer the whole system concerned;
- in a multi-persons decision framework, the impacts of the successive decision-makers involved can be precisely assessed either by defining an aggregate decision rule (by way of voting, e.g.) or by estimating the relative power influence of the individuals or sub-groups (see for instance, Blair (1979), Saaty (1977) and Shapley and Shubik (1954));
- the objective(s) and policy criteria relevant for the planning problem concerned, are exactly known (including their mutual trade-offs);
- spatial, social and intergenerational impacts of decisions to be made may be either neglected or assessed accurately via a spatial, social or dynamic distribution systems model;
- equity and distribution problems (between regions, groups or generations) can be taken into account by means of the policy objectives and the structure of the systems model at hand;
- the complex relationship between policy measures (instruments) and policy objectives (targets) are precisely known via an operational economic model describing the various relevant impacts;
- the technical, institutional, social and economic side-conditions of the system concerned are also precisely known and can be specified in an operational way (by means of constraints, e.g.);
- the time trajectory of all variables of the system within a reasonable time horizon can be computed precisely;
- when the state of a system is characterized by uncertainty (for instance, due to stochastic variables), the probability distribution of the stochastic elements is known, so that probability inferences can be drawn.

It is clear that in the practice of decision-making, the abovementioned conditions are hardly fulfilled, so that the determination of the optimal state of the system at hand is often an illusion. Consequently, traditional optimization models are increasingly receiving a very modest position in modern policy analysis. The attention of policy-makers appears to shift from optimality analyses towards impact analyses, effectiveness analyses and strategic decision analyses. In these analyses, much more emphasis is placed on effects of policy measures, on shifts in social objectives, and on conflict management and compromise principles.

In several recent publications, it has been stated that modern policy analyses have to be multidimensional in nature (see Nijkamp 1979, Nijkamp and Spronk, 1981, and Rietveld, 1980), as they have to take into account the existence of a wide variety of social interests, decision groups and policy structures. Such a broader view of policy analysis and policy processes requires an integrative framework for judging alternative policy options within a feasible decision space. Instead of designing optimizing systems, in recent policy analyses (Nijkamp, 1980) much more emphasis has been put on rationalizing systems by providing relevant information, by revealing conflicts among objectives or groups, by assessing trade-offs among different choice possibilities, by gauging the distributive impacts of policy measures, by identifying efficient (non-dominated) solutions, by designing suitable and relevant methods for policy evaluation, and by introducing learning principles. The current interest in interactive multidimensional programming models for policy analysis demonstrated clearly the new trends in designing and employing modern formal tools for decision-making. This issue will be further discussed in subsequent sections.

2. Elements of Policy Analysis

In the light of the abovementioned trends in policy analysis, in general, the following elements may be distinguished in setting up a policy analysis:

- the identification of policy objectives for the system concerned and of related judgement criteria for policy measures or instruments;
- the identification of all feasible alternative choice possibilities which are considered to be relevant for the policy problems in question;
- the assessment of all foreseeable and expected impacts of policy measures (or policy choices) upon the abovementioned objectives and criteria (for instance, by means of a formal structural model or a comprehensive impact system);

- the identification of interest groups and/or decision groups associated with the policy problem in question, as well as the identification or assessment of conflicts among diverging priorities;
- the assessment of policy priorities and/or weights attached by policy-makers to effects of measures taken by them;
- the development of appropriate evaluation methods and procedures (based on learning principles or strategic choice principles, e.g.);
- the treatment of information during the implementation stage of a policy plan so as to get insight into the sensitivities and/or shortcomings of the policy impact analyses used;
- an ex post evaluation of the actual policy decisions, their impacts and the role of the policy analysis concerned arriving at these decisions.

It should be noted that in practice, many of these elements cannot be realized, so that policy analyses usually have a partial nature. Given the abovementioned remarks about policy analysis, the following criteria may be specified for a meaningful and practical policy analysis:

- it should be able to assess the effects of decisions or measures to be taken on policy objectives and/or criteria of the systems at hand;
- it should provide a complete picture of relevant policy objectives, so that direct and indirect, intended and unintended impacts are included;
- it should reflect the variety and multidimensionality of the components of the system concerned;
- it should be flexible, so that the policy analysis can easily be adjusted to new circumstances or to new information;
- it should be comprehensible for the decision-makers and/or interest groups;
- it should be able to employ all available data in an efficient way (including 'soft' or qualitative data);
- it should, beside efficiency criteria, take into account equity and/or other relevant social distribution criteria;
- it should pay attention to conflicts among objectives, (interest)groups or other subsystems of the entire system;
- it should try to assess trade-offs among different policy objectives; (by weighting procedures, e.g.);
- it should leave possibilities for a learning strategy and feedback mechanisms in an (interactive) planning approach;
- it should be able to provide an integrated and systematic picture of all interactions and effects within the system at hand;
- it should open ways for compromise policies in case of policy conflicts;
- it should try to take take account of the institutional structure of decisions in the existing policy framework;

- it should try to formulate a meaningful decision space for achieving a satisfactory solution, based on either optimizer of satisficer principles.

All these criteria will of course never entirely be satisfied, but it will be shown in the next section that models for policy analysis can be designed that fulfil many of the abovementioned criteria.

3. Models for Policy Analysis

A model usually provides a stylized picture of a part of a complex reality. Clearly, models in a policy analysis should be able to indicate the boundaries within which policy decisions are to be made, the trade-offs inherent in choosing alternative solutions, the impacts of policy measures on a (normally large) set of policy objectives, and the possibilities for an interplay between experts and policy-makers.

Usually such a model is composed of a set of mathematical equations describing the functioning of the system (cf. Tinbergen, 1956), but this is not always necessary. Even impact systems and graph-theoretic representations might provide useful information (see Blommestein and Nijkamp, 1981), while also soft information can be meaningfully taken into account by means of soft econometric models (see Nijkamp and Rietveld, 1981).

Suppose now the following formal structural model containing a vector of decision variables $\underline{z}$ (instruments, e.g.), of policy objectives $\underline{w}$ (with elements w_i , $i = 1, \ldots, I$), of endogenous variables $\underline{x}$, and of endogenous or predetermined data $\underline{v}$:

$$\underline{f}\ (\underline{z}, \underline{w}, \underline{x}, \underline{v}) = \underline{0} \tag{1}$$

Then the following reduced form for the objectives may be assumed :

$$\underline{w} = \underline{g}\ (\underline{z}, \underline{v}) \tag{2}$$

Furthermore, a set of constraints (technical, social, political, economic, etc.) on the control variables of the system may be specified :

$$\underline{z} \in K \tag{3}$$

where K represents a feasible area. Then an <u>efficient</u> (non-dominated or Pareto-optimal) solution may be defined as follows : $\underline{z} \in K$ is efficient, if no $\underline{z}^* \in K$ does exist, such that :

$$\underline{w}^* = \underline{g}\ (\underline{z}^*,\ \underline{v}) \geq \underline{w} \qquad (4)$$

and :

$$w_i^* = g_i\ (\underline{z}^*,\ \underline{v}) > w_i \qquad i \in \{1, \ldots, I\} \qquad (5)$$

Thus, an efficient solution implies that no other feasible policy exists, which is for all policy criteria at least equally good and for at least one criterion better (cf. Despontin, 1980). Normally, one may expect that any good policy should be an efficient solution (although sometimes - due to political reasons or uncertainties - also non-efficient solutions are being chosen; cf. Leibenstein, 1976).

In general, a meaningful policy analysis should focus the attention in particular on the efficiency frontier (i.e. the set of efficient solutions) in order to identify a policy that will not be dominated by other policies. This is especially important in the framework of interactive policy models which usually aim at finding a compromise solution located on the efficiency frontier. This will be discussed later.

4. Policy Objectives

The exposition in the foregoing section was based on the assumption that policy objectives can easily be identified and are given prior to the actual use of the model. In reality, however, neither the analysts nor the decision-makers have a perfect insight into the various objectives to be considered as relevant aims in a policy analysis. Clearly, official reports or documents of policy-makers may give some indications concerning objectives to be reached, but these are often defined in a fuzzy or unstructured way, so that they leave open many interpretations (especially when general objectives have to be translated into operational policy criteria). Moreover, during the process of policy analysis itself, new insights are obtained which may lead to reorientation and respecification of policy aims and/or criteria. Of course, it might, in principle, be possible to include policy aims as 'hard' constraints, but this runs the risk of excluding policy flexibility from the model. Consequently, it is recommendable to include policy aims - whenever possible - in the form of objective functions instead of constraints.

The choice and specification of objective functions are evidently a matter of political responsibility of decision-makers, but they are usually also co-determined by interests of other groups implying also conflicts among objectives : conflict analysis is an essential ingredient of policy analysis. Multiobjective decision theory appears to provide a meaningful framework for taking account of conflicts among multiple objectives.

Furthermore, whenever possible, the policy objectives taken into consideration should not only refer to traditional welfare indicators (such as income or employment), but should also pay attention to 'soft' social or environmental indicators, so that the policy analysis at hand is based on a broad and balanced spectrum of policy issues and considerations. In this respect, a policy analysis may contribute substantially to gaining also more insight into the political feasibility of compromise solutions, especially in the framework of an interactive policy approach with multiple objectives. This will be discussed in the next section.

5. Interactive Policy Models

Interactive policy models take for granted that many problems in a policy analysis do not require an unambigious solution that represents once and for all the optimal state of the system concerned.
In light of the process character of many planning problems, an interactive policy analysis is certainly a reasonable approach. This approach is usually composed of a series of steps based on a systematic exchange of information between decision-makers and analysts (or experts). These interactive approaches have normally two steps in common:

- the analysts provide meaningful information and propose feasible trial solutions on the basis of a well defined compromise procedure;
- the decision-makers respond to each trial solution by indicating in which direction (i.e., in regard to which effects) the proposed compromise is still unsatisfactory.

These steps of an interactive policy procedure can be successively repeated, until after a series of steps a final satisfactory compromise solution has been identified. Recently, a large number of interactive models has been developed (see, for a study, among others, Rietveld, 1980 and Spronk, 1981).

Such interactive policy models which have already demonstrated their usefulness on several occasions have many significant advantages compared to traditional single-objective optimization methods :

- they are in agreement with the process character of the majority of current planning problems ;
- they are built on learning principles and feedback mechanisms for decision-makers;
- they provide necessary and meaningful information in a systematic and stepwise way;
- they take into account the limited capability of the human mind to judge complex planning problems with many choice options in one step;
- they emphasize the active role of decision-makers in specifying and solving choice problems, inter alia by making policy objectives more explicit and measurable;
- they are able to take account of the variety and the conflicting nature of policy options or decision criteria in planning problems;
- they allow an assessment of (implicit or explicit) trade-offs in many choice situations, without necessarily requiring a quantitative specification of weights;
- they provide an integrative framework for choosing consistent compromise solutions in complex and conflicting decision situations;
- they may be used to eliminate successively less relevant alternative choice options (for instance, by a dominance or strength-weakness analysis);
- they may fit into an institutional structure characterized by multiple decision-makers, various decision levels or long-lasting planning procedures.

In conclusion, interactive policy models may provide a coherent, operational and systematic contribution to a scientific rationalization of complex policy problems in reality. In the next paragraph, more explicit attention will be devoted to one of the recently developed interactive policy models, viz. interactive multiple goal programming.

6. Interactive Multiple Goal Programming (IMGP)

Suppose the following multiple goal programming problem:

$$\max \quad g_i(\underline{x}) \qquad \forall i$$

$$\text{subject to} \quad A\underline{x} \geq \underline{b} \qquad , \qquad (6)$$

where $\underline{x}$ is a vector of instrumental variables (see also (2)). There is a wide variety of methods dealing with such problems.
One of the methods for dealing with multiple goal functions is <u>interactive multiple goal programming</u> (IMGP) (see Nijkamp and Spronk, 1980, and Spronk, 1981).

The basic idea of IMGP is, that the decision-maker provides information about the desired state of the system on the basis of a provisional solution and a potency matrix presented to him. The potency matrix is made up by 2 vectors, representing respectively the <u>pessimistic</u> and <u>ideal</u> solution. For each goal variable separately, the pessimistic solution represents a minimum acceptable value (usually proposed by the decision-maker), whereas the ideal solution represents the individual maximum values, given the pessimistic solution. The decision-maker has to indicate whether or not a solution is satisfactory to him. If he judges a solution as unsatisfactory, he has to indicate which of the minimum goal values should be increased in value. Next, a new solution is presented to him together with a new potency matrix. The decision-maker has to indicate whether the shifts in the proposed (trial) solution are outweighted by the corresponding shifts in the potency matrix. If not, again a new trial solution is calculated and so forth, until a satisfactory solution has been found.

For the ease of presentation, the method is here described by assuming that in each iteration only one element of the solution may alter. A generalization to more elements is straightforward, however.

<u>Step 1</u>

Maximize each individual variable $g_i(\underline{x})$; denote the maximum by g_i^* and the I resulting values of the instrumental variables by $\underline{x}^{i*}$, $i = 1, \ldots, I$. It will never be possible to find a feasible value of $g_i(\underline{x})$ that exceeds g_i^* . Generally, it is not necessary to accept a value of $g_i(\underline{x})$ which is lower than g_i^{min} , defined as follows:

$$g_i^{min} = \min_j \{g_i(\underline{x}^{j*})\} \quad , \quad j = 1, \ldots, I \qquad (7)$$

This is the lowest value of $g_i(\underline{x})$ resulting from the successive maximizations of all individual goal variables. Next, the final solution S^* must be located between the 'ideal' (but normally unfeasible) solution I , and the 'pessimistic' solution Q . These solutions are respectively defined as:

$$\left.\begin{array}{l} I = [g_1^* , g_2^* , \ldots, g_I^*] \\ Q = [g_1^{min} , g_2^{min} , \ldots, g_I^{min}] \end{array}\right\} \text{ and } \qquad (8)$$

To facilitate the notation we have included the ideal solution I and the pessimistic solution Q in a $(2 \times I)$ potency matrix P .

Step 2

Define for all $j = 1, \ldots , I$ the following discrepancy value :

$$\delta_j = g_j^* - g_j^{min} \qquad (9)$$

Step 3

Define the initial solution as follows:

$$S_1 = [g_1^{min} , g_2^{min} , \ldots, g_I^{min}] \qquad (10)$$

which is thus equal to the pessimistic solution defined in (8).
Present the latter solution together with the potency matrix P_1 to the decision-maker.

Step 4

If the proposed solution satisfies the decision-maker, one may terminate the procedure; otherwise, define R_i as the subset of R defined by the goal levels in S_i , and proceed to step 5.

Step 5

The decision-maker has to answer the question : 'Given the provisional solution S_i , which goal variable should first be improved?' He needs not indicate himself how much this goal variable should be increased.

Step 6

Assume that the decision-maker wants to increase the j-th goal variable in value. Construct then a new trial solution $\hat{S}_{i+1}$, which differs from S_i only in the value of the j-th goal variable (denoted by $g_j(\underline{x})\hat{S}_{i+1}$ and $g_j(\underline{x})_{S_i}$ respectively). Next one may define:

$$g_j\ (\underline{x})_{\hat{S}_{i+1}} = g_j\ (\underline{x})_{S_i} + \tfrac{1}{2}\ \delta_j \quad , \tag{11}$$

followed by introducing the following restriction:

$$g_j\ (\underline{x}) \geq g_j\ (\underline{x})_{\hat{S}_{i+1}} \tag{12}$$

Step 7

Combine the restriction described in step 6 (or in step 9) with the set of restrictions describing the feasible region R_i . Calculate a new potency matrix, like in step 2, but subject to the new set of restrictions. Denote this potency matrix by $\hat{P}_{i+1}$.

Step 8

Confront next the decision-maker with S_i and $\hat{S}_{i+1}$ on the one hand, and with P_i and $\hat{P}_{i+1}$ on the other hand. The shifts in the potency matrix can be viewed as a 'sacrifice' trade-off for reaching the proposed trial solution. If the decision-maker judges this sacrifice to be reasonable, accept then the proposed solution by putting $S_{i+1} = \hat{S}_{i+1}$ and $P_{i+1} = \hat{P}_{i+1}$, and specify: $\delta_j = \tfrac{1}{2}\delta_j$. Continue with step 4. If the decision-maker regards the sacrifice as unjustified, the proposed initial value of $g_j\ (\underline{x})$ is obviously too high.
In that case, one may drop the constraint added in step 7.

Step 9

Now we know that $g_j\ (\underline{x})_{S_i}$ is too low and that $g_j\ (\underline{x})_{\hat{S}_{i+1}}$ is too high in the decision-maker's view.
Set then δ_j equal to the difference between these two values. Then a new proposal value $\hat{S}_{i+1}$ is calculated according to (11).
Like in step 6, we add the restriction that $g_j\ (\underline{x})$ must equal or exceed the new proposal value, and proceed to step 7.

A flow chart of the IMGP procedure is given in Figure 1. The method is entirely operational and has been used in various real-world planning problems[1]. For further details on IMGP (inclusion of aspiration levels, etc.) the reader is inferred to Nijkamp and Spronk (1980) and Spronk (1981).

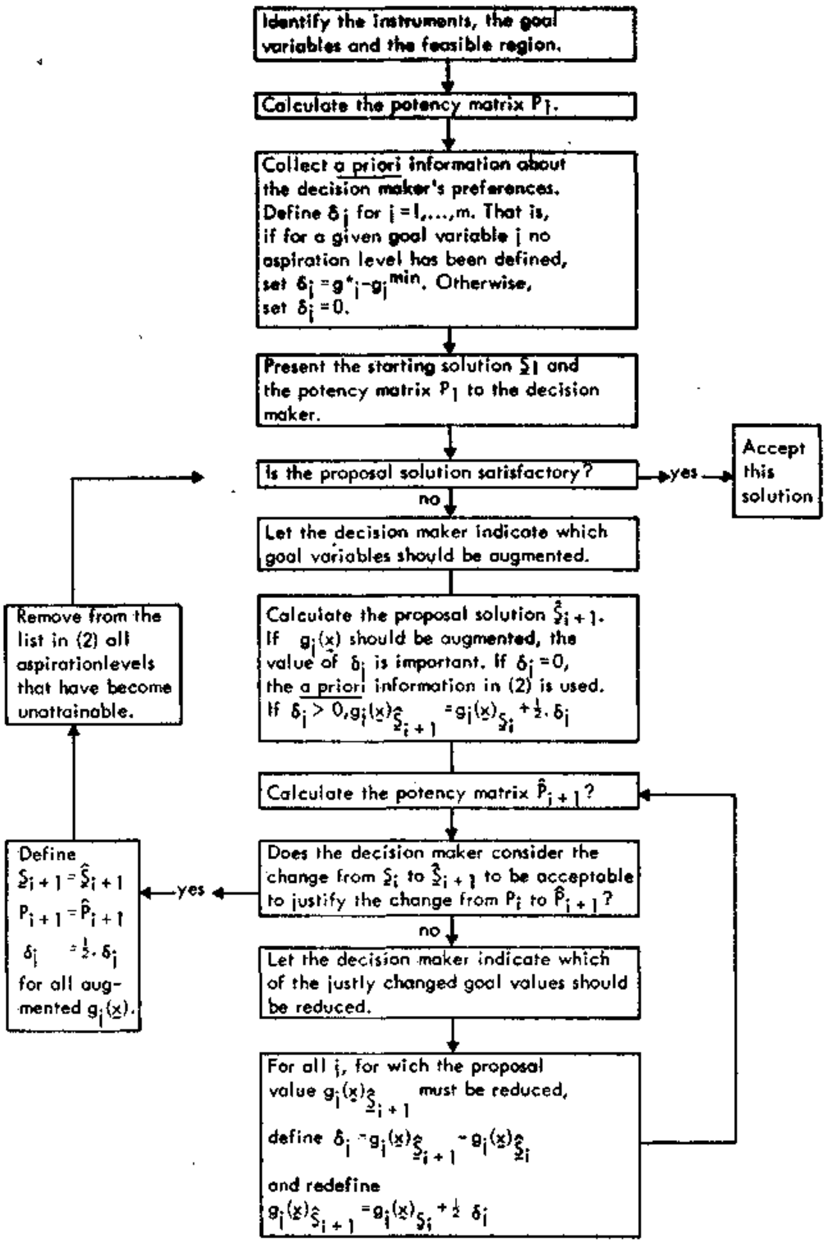

Figure 1. Flow chart of the interactive procedure.

[1] The authors acknowledge the stimulating co-operation with Professor J.A. Hartog during the computerization and implementation phase of this interactive method.

7. Illustration : A Model for Western Europe

The use of IMGP will be clarified by presenting some results from an integrated economic-environmental model. The model used in this empirical illustration was designed for a major industrial heartland in Western Europe, made up by the areas The Netherlands, Belgium, Nordrhein-Westfalen and France Nord, by Van Driel et al. (1980). This part of Western Europe contains approx. 45 million inhabitants in an area of 115,000 square kilometers. In this industrialized and densely populated area, various conflicting options regarding economic growth, environmental conditions and energy availability are most likely to emerge and have led to serious frictions in the past.

Van Driel et al. (1980) have developed a dynamic economic sectoral model based on an input-output framework. The description of this model will not be repeated here, but only some general features will be outlined.
The number of industrial sectors in this model was 17 (see Table 3). The structure of this input-output model, formulated as an inequality condition, is:

$$\underline{q}_t \geq (A+D)\, \underline{q}_t + K\, (\underline{w}_{t+1} - \underline{w}_t) + \underline{v}_t \qquad (1)$$

where:

$\underline{q}_t$ = vector of sectoral production levels in year t

$\underline{w}_t$ = production capacity in year t

$\underline{v}_t$ = final demand and export surplus in year t

A = matrix of Leontief input-output coefficients

D = matrix with sectoral depreciation coefficients for capital

K = matrix of sectoral capital coefficients .

Clearly, the following condition holds:

$$\underline{x}_t \leq \underline{w}_t \qquad (2)$$

This basic model has been extended with both a pollution model describing the emission of 4 kinds of pollutants (waste water, sulphur dioxide, solid waste, and pollution from cars) and a corresponding pollution abatement technology [1]. In addition, the dynamic input-output model was completed by means of capital and depreciation coefficients based on a so-called vintage model. The model does not contain straightforward behavioural equations; instead, policy options have been formulated in the form of inequalities, for instance, regarding productive capacity (i.e., the capital stock) and environmental pollution. The planning horizon of the model was supposed to be 10 years. After the specification of an appropriate objective function, this model can be treated as either a year-to-year programming model or a 10-year model. This model has been used as a framework for an interactive policy analysis set out in the previous paragraphs.

The experiments with this interactive model were induced by a project of the Dutch Scientific Council for Public Policy (abbreviated as WRR; see WRR, 1980). Consequently, the above mentioned IMGP approach was chosen as a tool for obtaining more insight into the conflictive nature of different policy objectives, the feasibility of certain economic policy scenarios, and the (in)stability of the results of the model for alternative policy variants. This Council also provided the information on policy objectives, constraints and various scenarios.

After a long discussion, six goal variables have ultimately been selected for an interactive policy analysis according to the above mentioned approach.

I.	employment	:	maximization of the total wage sum over the planning horizon;
II.	growth	:	minimization of the difference between the actual growth rate of production and a 3 per cent annual target growth rate of production;
III.	environmental quality	:	minimization of pollution by introducing a desired negative growth path for each pollutant (varying from 5 to 10 per cent);
IV.	balance-of-payment	:	minimization of the maximum change in export surplus compared to a base year for each sector separately;
V.	overall equilibrium on the balance-of-payment	:	minimization of the total deficit over the entire planning period;

1) In fact, the pollution coefficients for a sector were expressed as the abatement costs per unit of production value of the sector concerned.

VI.	stability of consumption pattern :	minimization of the maximum annual decrease (or maximization of the minimum annual increase) for each sector.

Apart from these goal variables some specific policy constraints have been introduced:

a. The annual change of the production level in the conventional sectors was allowed to fluctuate between a maximum annual decrease of 5% and a maximum annual increase of 10%.

b. The annual growth of the total consumption level should equal or exceed 1 percent per year. Given the expected growth in population, this is a necessary condition to maintain the per capita consumption level.

On the basis of this set of 6 objective functions and policy constraints, a series of experiments with interactive policy strategies has been carried out in the framework of the above mentioned WRR study. Some results of this IMGP approach will be described in the next section.

8. Experiments with the Interactive Policy Model

In recent years, multiple criteria decision methods have been employed as usefool tools in various integrated planning models in Western Europe (see Despontin, 1980 and Hartog et al., 1980, for overviews). Various experiments with a small scale version of the model described in the preceding section were carried out prior to the implementation of the complete model. As a first start of the interactive policy analysis, a fully operational version of this (simplified) interactive policy model was demonstrated to various experts and decision-makers in government and industry. It appeared that two main conclusions could be drawn from these initial deomonstrations: first, both experts and decision-makers regarded the interactive framework as a useful decision aid, among others because of the induced learning effects; secondly, as the input-output model proposed by Van Driel et al. (1980; see the preceding section) does not include any behavioural relationship, clearly the results depend only on the technical relations, the added side-conditions and the decision-maker's evaluations. These technical relationships and constraints are rather 'hard' and reflect the maximum permissible state of the system, so that one may conclude that - if a certain combination of the objectives is not feasible within the model - this combination is certainly not feasible in the real world.

On the other hand, if a certain combination of objectives turns out to be feasible within the model, it is not certain - because of the omitted behavioural relationships - that this combination can be realized in practice. In summary, the results obtained by means of this interactive policy model are rather hard, at least stated in a negative sense ('falsification').

The first experiments with the small-scale version of the model proved already the usefulness and operationality of the IMGP approach. More details of the above mentioned small version of the model are given by Hartog et al., 1980.

Next, on the basis of these experiments the Dutch Scientific Council for Public Policy (WRR) decided to implement the IMGP procedure in combination with the complete version of the Western Europe model described in the preceding section. Because this project had to be carried out within a limited time period and because the experiences with interactive procedures were not yet related to large scale models, the results of the experiments were not as satisfactory as they could have been under ideal circumstances (see Hartog and Spronk, 1980, and WRR, 1980, for details).

Nevertheless, the results were judged to be very instructive. Besides, several conclusions could be drawn which turned out to be helpful in new experiments with interactive modelling (for instance, a new study of the WRR uses an adapted version of the above mentioned methodology). Hereafter, we will present part of the results of the above mentioned experiments, followed by the description of some lessons learned from them in the following section.

In Table 1, the successive sets of limit goal values ('pessimistic' solutions), subject to which each goal variable had to be optimized separately at each iteration, are given. All figures represent billions of Dutch guilders (1965), except those related to the third goal variable which is measured in percentages. Because in the first iteration the unconditional optimal solutions are calculated, initially no pessimistic goal values are given. Until the fifth iteration, no pessimistic goal value is given for goal variable 6, because until this very iteration it was provisionally (but after all uncorrectly) assumed that the balance-of-payment deficit could be decreased implicitly by means of the other goal variables. In fact, awareness of this mistake can be considered to be one of the learning effects obtained by using the interactive policy model.

Table 1. Sets of limits on the goal variables

goal variable		1	2	3	4	5	6	7	8	9	10
employment	1	-	300	350	350	350	350	350	350	350	350
deviation from growth target	2	-	19	10	10	10	10	10	10	10	10
deviation from pollution decrease target	3	-	50	25	25	25	15	5	5	5	5
maximum change in sectoral export-surplus	4	-	16	5	1	1	1	1	1	1	1
total balance-of-payment deficit	5	-	10	5	5	5	5	5	0,1	5	0,1
maximum decrease of sectoral consumption	6	-	-	-	-	10	10	10	10	5	5

More interesting than the pessimistic goal values are the optimal values which can be obtained by taking account of the pessimistic goal values. In Table 2, three examples are given. The set of goal values A is obtained when the first goal variable is maximized in the 10-th iteration subject to the corresponding set of limits in Table 1. The set of goal values B is obtained when the 6-th goal variable is minimized in iteration 7 and set C is obtained when the third goal variable is minimized in the 7-th iteration.

Table 2. Some illustrative outcomes

goal variable	A	B	C
1	513	439	350
2	10	10	10
3	5	5	4.6
4	1	1	1
5	5	10	0
6	0.1	0.33	0.23

The decision-makers were not only interested in the values of the goal variables, but also (and maybe even more) in the values of the instrumental variables. In other words, they wanted to know by means of which sectoral structure of the industry the chosen combination of goal variables could be reached. To illustrate this for the three sets of goal variables A, B and C (presented in Table 2), the average rate of change in the annual level of production of each of the industrial sectors is given in Table 3.

For a much more detailed report of these results we refer to WRR (1980). Here, it should be stressed that - given the pessimistic goal values in iteration 10 - still many alternatives are feasible. These remaining alternatives were not studied in greater detail in this study. This was partly due to the limited time available for the study. However, a much more important reason was that the obtained results had given new insights to both experts and decision-makers. It was felt that new restrictions should be added to the model and that some of the goal variables should be reformulated.

Table 3. Average annual rate of change (in %) of the sectoral production levels *

set of goal values	A	B	C
1. Agriculture	0.5	7.2	-4.7
2. Energy	6.4	1.3	0.8
3. Ores	8.7	0.3	-2.4
4. Minerals	9.0	7.4	-0.4
5. Chemical products	8.4	6.8	-3.6
6. Metal	9.0	4.7	5.3
7. Means of transport	8.4	5.3	4.0
8. Foods	6.1	6.7	-3.3
9. Textiles	8.4	8.4	3.1
10. Paper	8.4	8.4	-3.6
11. Various products	9.0	9.0	-5.0
12. Building	9.0	-3.0	-0.4
13. Commerce	9.0	5.8	-1.1
14. Transport	9.0	6.0	3.5
15. Money affairs	9.0	2.7	4.3
16. Other market services	-1.8	-5.1	-3.6
17. Administration	7.3	-0.5	1.3

Especially the formulation of the second goal variable, viz. growth of production, turned out to be inadequate. First, it appears to be not clear why, a priori, a growth rate of exactly 3 per cent should be aimed at. Secondly, no difference was made between the directions of the deviations from this growth rate : both positive and negative deviations had to be minimized in the original policy formulation of the decision-makers.

The outcomes did also suggest that different formulations of goal variables which are defined in terms of growth paths may give rise to very different results. For instance, the first (simplified) study had shown that - within the framework of the model - the desired environmental quality can be reached without any problem, whereas the second more complete study showed that the

* Sources: WRR, 1980, p. 158.

choice of the time path, along with the desired environmental quality should be reached, is more restrictive for the economic system. Furthermore, within a 10-period policy model incorporating many sectors, the number of goal variables tends to become unmanageable. Therefore, some of the goal variables were formulated in a minimax sense, i.e. as the maximum deviation (to be minimized) from a target growth path. In principle, all these deviations may be scaled in different dimensions. Thus many different ways to handle the problem of large numbers of goal variables do exist, which are not yet studied in full detail. The sensitivity of results for alternative numbers or specifications of objectives is no doubt a study area that deserves much attention in policy analyses.

9. Lessons

The above mentioned IMGP model has provided many highly interesting experiences with integrated complex planning problems, so that several important lessons can be drawn. The main conclusion is that interactive policy models can be an important and operational decision aid for the practice of policy-making and conflict management. It should be stressed that the primary purpose of these models is not to provide 'good' or even 'optimal' solutions (although formally speaking, this kind of solutions can be provided by these models), but that the major advantage of these models is that they can be an important learning tool, for both decision-makers and experts.

This is especially true because in practice very often no exact goal definitions do exist. Interactive policy models can help to define the decision-maker's goals more explicitly and to induce an awareness of interdependencies in complex systems.

Furthermore, as it is not always easy to identify the decision-maker(s), interactive policy models may serve as a flexible means of communication in an institutional policy setting with many interest and decision groups.

REFERENCES

Blair, P.D., Multiobjective Regional Energy Planning, Kluwer Nijhoff, Boston, 1979.

Blommestein, H.J., and P. Nijkamp, Soft Spatial Econometric Causality Models, Research Memorandum, Dept of Economics 1981-14, Free University, Amsterdam, 1981.

Despontin, M., Kwantitatieve Economische Politiek vanuit een Besluitvormingsoptiek, Ph. D., Free University, Brussels, 1980.

Driel, G.J. van., J.A. Hartog and C. van Ravenzwaaij, Limits to the Welfare State, Martinus Nijhoff, Boston/The Hague, 1980.

Hartog, J.A. and J. Spronk, Een Modelstudie naar de Relatie Milieu-Economie, Working Document WRR, Staatsuitgeverij, The Hague, 1980.

Hartog, J.A., P. Nijkamp and J. Spronk, Operational Multiple Goal Models for Large Economic Environmental Systems, Proceedings of the IX-th IFIP Conference on Optimization Techniques, Vol. II, K. Iracki et al., eds., Springer, Berlin, 1980, pp. 502-512.

Leibenstein, H., Beyond Economic Man, Harvard University Press, Cambridge, 1976.

Nijkamp, P., Multidimensional Spatial Data and Decision Analysis, John Wiley, New York/Chichester, 1979.

Nijkamp, P., Environmental Policy Analysis, John Wiley, New York/Chichester, 1980.

Nijkamp, P., and P. Rietveld, Ordinal Multivariate Analysis, Professional Paper 81-2, IIASA, Laxenburg, 1981.

Nijkamp, P., and J. Spronk, Interactive Multiple Goal Programming : An Evaluation and Some Results, Multiple Criteria Decision Making : Theory and Application, G. Fandel and T. Gal, eds., Springer, Berlin, 1980, pp. 278-293.

Nijkamp, P., and J. Spronk, Multicriteria Analysis : Operational Methods, Gower, Aldershot, 1981.

Rietveld, P. Multiple Objective Decision Methods and Regional Planning, North-Holland Publ. Co, Amsterdam, 1980.

Saaty, T.L., Scaling Methods for Priorities in Hierarchical Structures, Journal of Mathematical Psychology, vol. 15, no.3, 1977, pp. 234-281.

Shapley, L.S., and M. Shubik, A Method for Evaluating the Distribution of Power in a Committee System, American Political Science Review, vol. 48, 1954, pp. 787-793.

Spronk, J., Interactive Multiple Goal Programming : Applications to Financial Planning, Kluwer Nijhoff, Boston, 1981.

Theil, H., Optimal Decision Rules for Government and Industry, North-Holland Publ. Co, Amsterdam, 1968.

Tinbergen, J., Economic Policy : Principles and Design, North-Holland Publ. Co, Amsterdam, 1956.

WRR, Plaats en Toekomst van de Nederlandse Industrie, Staatsuitgeverij, The Hague, 1980.